B. Specification

Please amend the paragraphs at page 1, line 5, through page 6, line 3, as follows:

The present invention relates to a method for producing a liquid discharge head for discharging a liquid droplet such as an ink droplet, thereby forming a record on a recording medium, and more particularly to a method for producing a liquid discharge head for ink jet recording.

Description of the Related Art

The ink jet recording method is one of the so-called non-impact recording methods. Such an ink jet recording method generates ~~only little noises of~~ almost negligible ~~level at the recording,~~ noise during recording and is capable of ~~a~~ high speed recording. Also the ink jet recording method is capable of recording on various recording ~~media,~~ media and achieving ink fixation even on so-called plain paper to provide a high definition image inexpensively. Based on these advantages, the ink jet recording method ~~is~~ has become widespread recently ~~spreading widely~~ not only in a printer constituting ~~a~~ peripheral computer equipment ~~of the computer~~, but also as recording means for a copying machine, a facsimile apparatus, a word processor, etc.

For achieving ink discharge in the commonly utilized ink jet recording method, ~~there are known a method~~ methods of employing, as an element for generating a discharge energy to be used for discharging an ink droplet, an electrothermal converting element such as a ~~heater, and a method of employing~~ heater or an electromechanical converting element such as a piezo ~~element, and the~~ element are known. The discharge of the ink droplet can be controlled by an electrical signal in either method. The ink

discharging method employing the electrothermal converting element is based on a principle of applying a voltage to the electrothermal converting element, thereby causing the ink in the vicinity of the electrothermal converting element to boil ~~instantaneously;~~ instantaneously and discharging an ink droplet at a high speed by a rapid growth of a bubble generated by a phase change in the ink at ~~the~~ boiling. On the other hand, the ink discharge method utilizing the piezoelectric element is based on a principle of applying a voltage to the piezoelectric element, thereby causing a displacement therein and discharging an ink droplet by a pressure generated by such displacement.

The ink discharge method utilizing the electrothermal converting element has advantages of not requiring a large space for providing the discharge energy generating ~~element;~~ element and of a simple structure of the liquid discharge head, enabling easy integration of nozzles. On the other hand, such an ink discharge method is associated with ~~drawbacks;~~ drawbacks specific to this method, such as a fluctuation in the volume of the flying ink droplet by an accumulation in the liquid discharge head of the heat generated by the electrothermal converting element, a detrimental influence of a cavitation phenomenon caused by the extinction of the bubble on the electrothermal converting element, and a detrimental influence of air dissolved in the ink, forming bubbles remaining in the liquid discharge head and influencing the discharge characteristics of the ink droplet and the quality of the obtained image.

For solving these problems, Japanese Patent Application Laid-open Nos. 54-161935, 61-185455, 61-249768, and 4-10941 disclose an ink jet recording method and a liquid discharge head. The ink jet recording method disclosed in these references has a configuration in which a bubble, generated by driving an electrothermal converting element

with a recording signal, is made to communicate with the external air. Such an ink jet recording method enables ~~to stabilize~~ the stabilization of the volume of the flying ink droplet, ~~to discharge~~ the discharge of an ink droplet of an extremely small volume at a high speed, and ~~to eliminate~~ the elimination of the cavitation at the extinction of the bubble thereby improving the durability of the heater, thus allowing ~~to easily obtain~~ easier obtainment of an image of a higher definition. The aforementioned references disclose a configuration, for causing the bubble to communicate with the external air, in which a minimum distance between an electrothermal converting element and a discharge port is significantly reduced in comparison with a prior configuration.

Now there will be explained such a prior liquid discharge head. A prior liquid discharge head is provided with an element substrate on which an electrothermal converting element for ink discharge is ~~provided,~~ provided and an orifice substrate for constituting an ink flow path by being adjoined to the element substrate. The orifice substrate has plural discharge ports for discharging ink, plural nozzles in which the ink flows, and a supply chamber for supplying such nozzles with the ink. A nozzle is constituted of a bubble generating chamber for generating a bubble in the ink therein by an electrothermal converting ~~element,~~ element and a supply path for supplying the bubble generating chamber with the ink. The element substrate is provided with an electrothermal converting element so as to be positioned in the bubble generating chamber. The element substrate is also provided with a supply aperture for supplying the supply chamber with the ink from a rear surface opposite to a principal plane adjacent to the orifice substrate. Also, the orifice substrate is provided with a discharge port in a position opposed to the electrothermal converting element provided on the element substrate.

In the prior liquid discharge head of the above-described configuration, the ink supplied from the supply aperture to the supply chamber is supplied along each ~~nozzle,~~ nozzle and is filled in the bubble generating chamber. The ink filled in the bubble generating chamber is caused to fly, by a bubble generated by a film boiling caused by the electrothermal converting element, in a direction substantially perpendicular to the principal plane of the element ~~substrate,~~ substrate and is discharged from the discharge port.

In a recording apparatus equipped with the aforementioned liquid discharge head, a higher recording speed is being investigated for achieving a higher quality, a higher definition and a higher resolution in the recorded image. For increasing the recording speed in the prior recording apparatus, U.S. Patents Nos. 4,882,595 and 6,158,843 disclose a method of increasing a number of discharges of the flying ink droplets in each nozzle of the liquid discharge head, namely increase a discharge frequency.

In particular, ~~the~~ U.S. Patent No. 6,158,843 proposes a configuration of improving the ink flow from the supply aperture to the supply path, by providing a space for locally constricting the ink flow path and a projection-shaped fluid resistance element in the vicinity of the supply aperture.

Please amend the paragraph at page 7, lines 5-11, as follows:

In consideration of the foregoing, an object of the present invention is to provide a liquid discharge head capable of achieving a higher discharge speed of a liquid droplet and stabilizing a discharge amount of the liquid droplet, thereby improving a discharge efficiency for the liquid droplet, and a producing method therefor.

Please amend the paragraph at page 9, line 8, through page 10, line 7 as follows:

The liquid discharge head thus obtained is so constructed that a flow path within a nozzle varies in a height, a width or a ~~cross-section,~~ cross-section and that an ink volume gradually decreases in a direction from the substrate to the discharge port, and a vicinity of the discharge port is so constructed that a flying liquid droplet flies perpendicularly to the substrate and that a flow rectifying effect is realized. Also at the discharge of a liquid droplet, it is possible to suppress a push-out of the liquid in the bubble generating chamber by the bubble generated therein toward the supply path. Therefore, such a liquid discharge head can suppress the fluctuation in the discharge volume of the liquid droplet discharged from the discharge port, thereby securing an appropriate discharge volume. Also in this liquid discharge head, at the discharge of a liquid droplet, because of a presence of a control portion constituted by a step difference portion, the bubble growing in the bubble generating chamber comes into contact with an internal wall of the control portion in the bubble generating chamber, whereby a pressure loss of the bubble can be suppressed. Therefore, such liquid discharge head allows satisfactory growth of the bubble in the bubble generating chamber to ensure a sufficient pressure, thereby improving the discharge speed of the liquid droplet.

Please amend the paragraphs at page 11, line 6, through page 12, line 23, as follows:

Figs. 8A, 8B, 8C, 8D and 8E are perspective views showing a method for producing the liquid discharge head of the first embodiment of the present invention,

~~wherein:~~ wherein Fig. 8A shows an element substrate; Fig. 8B shows a state where a lower resin layer and an upper resin layer are formed on the element substrate; Fig. 8C shows a state where a covering resin layer is formed; Fig. 8D shows a state where a supply aperture is formed; and Fig. 8E shows a state where internal lower and upper resin layers are dissolved out;

Figs. 9A, 9B, 9C, 9D and 9E are first vertical cross-sectional views showing a method for producing the liquid discharge head of the first embodiment of the present invention, ~~wherein:~~ wherein Fig. 9A shows an element substrate; Fig. 9B shows a state where a lower resin layer is formed on the element substrate; Fig. 9C shows a state where an upper resin layer is formed on the element substrate; Fig. 9D shows a state where the upper resin layer formed on the element substrate is subjected to a pattern formation to obtain a slope on a lateral face; and Fig. 9E shows a state where the lower resin layer is subjected to a pattern formation;

Figs. 10A, 10B, 10C, and 10D are second vertical cross-sectional views showing a method for producing the liquid discharge head of the first embodiment of the present invention, ~~wherein:~~ wherein Fig. 10A shows a state where a covering resin layer constituting an orifice substrate is formed; Fig. 10B shows a state where a discharge port portion is formed; Fig. 10C shows a state where a discharge port is formed; and Fig. 10D shows a state where internal upper and lower resin layers are dissolved out to complete a liquid discharge head;

Fig. 11 is a chemical reaction formula showing chemical changes in the upper resin layer and the lower resin layer by ~~an~~ electron beam irradiation;

Please amend the paragraphs at page 13, line 16, through page 14, line 23, as follows:

Figs. 17A and 17B are partially cut-off perspective view showing a combination structure of a heater and a nozzle in a fourth embodiment of the liquid discharge head of the present invention, ~~wherein:~~ wherein Fig. 17A shows a nozzle in a first nozzle array; and Fig. 17B shows a nozzle in a second nozzle array;

Figs. 18A, 18B, 18C, 18D and 18E are first vertical cross-sectional views showing a method for producing the liquid discharge head of the fourth embodiment of the present invention, ~~wherein:~~ wherein Fig. 18A shows an element substrate; Fig. 18B shows a state where a lower resin layer is formed on the element substrate; Fig. 18C shows a state where an upper resin layer is formed on the element substrate; Fig. 18D shows a state where the upper resin layer formed on the element substrate is subjected to a pattern formation to obtain a slope on a lateral face; and Fig. 18E shows a state where the lower resin layer is subjected to a pattern formation; and

Figs. 19A, 19B, 19C, and 19D are second vertical cross-sectional views showing a method for producing the liquid discharge head of the fourth embodiment of the present invention, ~~wherein:~~ wherein Fig. 19A shows a state where a covering resin layer constituting an orifice substrate is formed; Fig. 19B shows a state where a discharge port portion is formed; Fig. 19C shows a state where a discharge port is formed; and Fig. 19D shows a state where internal upper and lower resin layers are dissolved out to complete a liquid discharge head.

Please amend the paragraph at page 30, lines 3-12, as follows:

The liquid discharge head 1, in case of employing for example a dye-based black ink (surface ~~tention~~ tension: 47.8 x 10^{-3} N/m, viscosity: 1.8 cp, pH: 9.8), can reduce the viscosity resistance B in the nozzle 27 by about 40 % in comparison with a prior liquid discharge head. The viscosity resistance B can be determined, for example, with a three-dimensional finite element method ~~solver,~~ solver and can be easily calculated by determining a length and a cross section of the nozzle 27.

Please amend the paragraph at page 74, lines 2-26, (Abstract) as follows:

The invention is to provide a liquid discharge head capable of achieving a higher liquid droplet discharge ~~speed, and a stabler~~ speed and a more stable discharge amount, thereby improving the discharge efficiency, and a producing method therefor. A liquid discharge head 1 includes a heater 20, an element substrate 11, a nozzle 27 including a discharge port portion 26 having a discharge port 26a for discharging a liquid droplet, a bubble generating chamber and a supply path for supplying the bubble generating chamber with the liquid, and an orifice substrate 12 including a supply chamber 28 for supplying the nozzle 27 with the liquid, wherein the bubble generating chamber is constituted of a first bubble generating chamber 31a and a second bubble generating chamber 31b provided thereon, the discharge port portion 26 is provided on and communicates with the second bubble generating chamber with a step difference thereto, the lateral wall of the second bubble generating chamber 32b is constricted toward the discharge port with an inclination of 10° to 45°, and the upper plane of the supply path is formed higher toward the supply

chamber, in order to increase the liquid amount in the supply path and to improve the temperature dependence of the discharge amount.